

SCOPE OF DOCUMENT

Planning, design and ecological considerations in process based natural channel design for habitat restoration, including channel configuration, riparian function, sediment transport, hyporheic function and flood plain connectivity. Channel design parameters are addressed, including specific habitats (spawning, rearing, holding, riparian, etc.), habitat forming structures, and off-channel habitats.

1 INTRODUCTION

1.1 *Historic Impacts to Watersheds*

Discuss impacts and their effects on streams.

1.2 *Watershed Restoration vs. Protection*

Use material from British Columbia manual at least in part.

2 HABITAT IMPROVEMENTS AS MITIGATION

2.1 *Habitats Commonly Affected by Channel Modifications*

Habitat is affected by development projects and may be positively or negatively impacted by beneficial habitat restoration projects. Either way, mitigation for the effects is necessary. This section is a description of potential impacts. An appendix provides additional biological detail.

2.1.1 *Spawning*

2.1.2 *Cover*

2.1.3 *Habitat Complexity and Diversity*

2.1.4 *Riparian Function*

2.1.5 *Flood Refuge*

2.1.6 *Sediment and Debris Sources*

2.1.7 *Off-Channel Rearing Habitat*

2.1.8 *Upstream and Downstream Channel-Stability Impacts*

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2.2 Duration and Extent of Impacts

2.2.1 Construction-Activity Impacts

2.2.2 Channel Response Impacts; On Site, Off Site

2.2.2.1 Lost-Opportunity Impacts

2.2.2.2 Management of Lost-Opportunity Impacts

Recognizing Lost Opportunity Impacts includes considerations of Expected Duration of the Impact, a Geomorphic/Riparian Basis and the Action/Treatment Being Considered

2.2.3 Impacts of Perceived Protection (bank protection, levees)

2.3 Mitigation

2.3.1 Legal and Policy Basis of Mitigation

2.3.1.1 Mitigation sequencing

Avoiding the Impact, Minimizing the Impact, and Compensating for unavoidable impacts

2.3.1.2 Mitigate for No Loss-of-Habitat Functions and Values

2.3.1.3 Mitigation for the Duration of the Impact

Reopening Mitigation for chronic maintenance or repair and Reopening Mitigation for Project Reconstruction

2.3.1.4 Probability of Mitigation Success and Delayed Mitigation

Mitigation Banking, Monitoring and Corrective Action, and Mitigation Ratios

2.3.1.5 Experimental Mitigation Techniques

2.4 Integrating Mitigation into Projects

2.4.1 Compensatory Mitigation Targets

2.4.1.1 Improvement of Limiting Factors

2.4.1.2 Properly Functioning Habitat

2.4.1.3 Restoration of Current Natural Conditions

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2.4.1.4 Restoration or Replacement to Pre-project Conditions

2.4.2 Quantifying Mitigation Needs

2.4.2.1 Methods

2.4.2.2 Habitat Value as Avoided Costs

3 DEVELOPING A REACH ANALYSIS

3.1 Introduction

- Define restoration; define habitat.
- Define and describe the components of a reach analysis and what it is intended for.
- Describe a typical resource assessment problem that has been addressed through a reach analysis.
- Provide recent examples of constructed reach analyses (projects completed by PWA? Sue Perkins? Interfluve?)
- Intended for 1) land managers confronted with specific problems that need technical evaluation, and 2) research and management applications.
- Define the requisite background and expertise for practitioners

3.2 Analysis of Reach Conditions

3.2.1 Define the Problem

Define the problem including a clear definition of objectives, level of effort, and necessary investigative studies.

3.2.2 Watershed Description

Assess watershed conditions according to the level of detail that matches resources as well as the risks of failure. Designers should attempt to determine (adapted from Brookes and Shields, Jr., 1996):

- Physical characteristics of the watershed and channel network. Geology; climate; hydrology; soils; land use; channel segmenting. Montgomery and Buffington (1993) provide a useful, process-oriented classification scheme for evaluating the distribution of channel segment types throughout the channel network.
- Characteristics of the existing hydrologic response and the likelihood for future shifts in water and sediment yield. Land use: urbanization, agriculture, timber management, mining.
- Existing instability in channel system and its causes. Kondolf and Sale (1985) provide a review of factors that can determine channel stability and induce channel change. This is a step that is difficult to over-emphasize. "When habitat restoration projects are planned on streams where habitat has been degraded as an indirect result of other factors, these other factors must be studied, understood, and explicitly accounted for in the design of restoration. If they are not, the

forces that destroyed the original channel are likely to undo the restored channel” (Kondolf, 1990).

- Likely instabilities in the design channel.

3.2.3 *Characterize Channel Reach*

3.2.3.1 Qualitative Characterization

- Acquire and review background information - aerial photographs, GLO survey maps, Secretary of War documents, topographic maps, plat maps, unpublished reports, theses and/or dissertations, peer reviewed articles, agency records, studies contracted to consulting firms, U.S. Geological Survey data
- Reconnaissance field visit(s)
- Subdivide reach into sub-segments based on relatively uniform characteristics (erosional environment, depositional environment, planform, gradient, confinement, sediment characteristics)
- Interpret aerial photographs and historical maps

3.2.3.2 Field Studies

- Selection of measurement sites. The success and utility of channel measurements usually depends strongly on the sites selected for measurements.
- Slope measurements
- Channel geometry measurements – include description of how to recognize bankfull stage
- Channel roughness
- Floodplain characteristics
- Sediment characteristics
- Vegetation characteristics

3.2.3.3 Analysis and Discussion

- Definition of flow characteristics – procedures for flow analysis (flow duration, flow frequency analysis) and characterizing stage-discharge relationships
- Identification of channel changes – determination of stream instability (channel bed, local and/or system-wide?)
- GIS analysis if appropriate (e.g., georeferencing channel positions through time on one base map)
- Assessment of historical and current conditions
- Evaluation of limitations to analysis, magnitude of error

3.2.4 Characterize Biological Conditions [needs an author]

3.3 Summarizing Results

3.3.1 Identify Causes of Altered or Impaired Condition

Generally what has happened and what has been the impact to habitat conditions. (5-7 pages).

This section will be more specific and detailed than comments in section 1.1. Table or flow chart to describe cause and effect of activities. (Consider using flow chart similar to what is in several of the white papers – look at the overwater structures paper. <http://www.wa.gov/wdfw/hab/ahg/finalfrs.pdf>)

Illustrate that cause and effect can be a complex situation, that effects may be result of multiple causes, rarely a simple relationship. Use a few examples where an observed effect may be a result of numerous causes. Use braided channel as an example.

Be sure to emphasize and include comprehensive coverage of effects of urbanization.

Include explicit language that addresses understanding the long-term evolution of a study reach before proposing and selecting restoration strategies.

Review ISPG reach analysis chapter. How much of it can we use or reference directly to? Can it be modified to apply to both guidelines?

3.3.1.1 Causes of Impaired Condition

- Disruption to process
- Spatial Scale – micro meso macro
- Temporal Scale –
- Landscape scale impacts – agriculture, forestry
- Development/urbanization – changes to hydrology and sediment supply
- Constraints on channel – levees, channelization, constrictions
- Loss of riparian

3.3.1.2 Impaired Conditions

- Habitat
- Loss of variability in habitat
- Loss of complexity in habitat
- Reduced period of disturbance

3.3.1.3 Specific Examples:

- For each example, discuss multiple possible causes:
- Braided channel
- Lack of pool habitat
- Lack of spawning gravels
- Lack of rearing habitat

3.3.2 *Existing vs. Desired Structure and Functions (reference condition)*

Discuss stream structure and function as well as holistic view of salmonid preferences. (2 pages).

Discuss departure from properly functioning condition.

Identify salmonid deficiencies through limiting factors analysis. In other words, what is the condition one has to work with? Recognize that limiting factor analysis may be overly species-specific and myopic, as it tends to be a collection of preference conditions as opposed to understanding systemic process.

3.3.2.1 General Habitat Requirements

- Food
- Water Quality
- Habitat Structure
- Flow Regime
- Biotic Interactions and Community Structure
- Population Structure
- In summary – all result from healthy process
- Review and refer to biological appendix from ISPG. It will be used as an appendix here. Describe here only what's relevant to restoration/mitigation. General biology is in the appendix because it will apply to all guidelines.

3.3.2.2 Processes that form and maintain habitat

- Discussion of process
- Relating process to habitat
- Relating habitat to fish
- Complexity
- “PFC”, Departure from PFC, relevance
- Limiting Factors Analysis – problems with it
- Natural
- Human-induced

3.3.3 Identify Constraints To Restoration and Mitigation

(3 pages – was 1 page)

Define restoration – return to previous condition of natural function

In this context, true restoration is difficult if not impossible in most watersheds due to either significant permanent watershed change, or site and reach constraints.

Define mitigation – mitigation targets; refer to Ch 3.2 – ideally mitigation has a similar functional objective as restoration. Other targets might be replacement of specific habitat features.

In addition to limits to recovery potential, there are limits to the recovery process or full mitigation due to logistical constraints related to natural systems

We have the current and future conditions of the watershed to work with.

3.3.3.1 Constraints to Natural Function

Constraints to natural function limit the true restoration potential and require careful consideration of impacts to channel process

3.3.3.1.1 Watershed Constraints

- Long-term or permanent change to hydrologic regime due to forestry, agriculture, or development. Scale; small watersheds more affected
- Long-term change to sediment supply and sediment characteristics
- Long-term or permanent change to the quality of LWD supply due to on-going timber management and/or LWD removal activities Scale; large rivers more affected because large debris missing.
- Degree of channel manipulation in lowland areas of the channel network
- Recovery potential is related to land management opportunity in less developed watershed
- Floodplain land use
- Even development that seems distant from the active channel may limit the channel to respond to major events

3.3.3.1.2 Reach and Site Constraints

- Infrastructure
- Property ownership limits options

3.3.3.2 Logistical Constraints

Logistical constraints refer to limits to options of actual restorative and mitigation actions

- Seasonality of construction windows
- Time to maturity for vegetative treatments/restoration – delayed mitigation; refer to Ch 3.2

- Off-site restoration factors associated with salmonids – much of their life history occurs in other reaches or in the ocean – off-site mitigation might be appropriate if it more effectively affects productive capability; refer to Ch 3.2
- Scale of what real restoration would be – can part of the project be done at a time or does the entire channel and reach have to be addressed? There is uncertainty here also that drives us to do little projects that never resolve the reach-scale problem.

3.4 Characterizing the Watershed – Structure and Process

3.4.1 Heading Placeholder – Do Not Delete

3.4.2 Identify Causes of Altered or Impaired Condition

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4 SELECTING A RESTORATION OR REHABILITATION APPROACH

Approaches to restoration or rehabilitation are necessarily as unique as the rivers they are aimed at

Restoration and rehabilitation approaches must accommodate unique:

- Stream system and watershed
- Societal constraints
- Multi-party objectives

4.1 Problem Identification

(2-3 pages for following sections 4.1.1 to 4.1.4 in total)

4.1.1 Define Problem (on site, reach, and watershed scale)

Habitat may be limited by site, reach and watershed scale problems. Restoration/rehabilitation plans or habitat improvement plans must identify problems as part of process of developing solution

Watershed scale problems:

- Changes in hydrology or sediment supply or both
- Changes in vegetative cover and impervious surface conditions in the watershed

Site and Reach scale problems

- Changes in boundary conditions
- Physical modification of channel
- Process constraints – limits to lateral or vertical process

4.1.2 Define Objectives

Emphasize holistic perspective on objectives.

Objective of most habitat restoration is to enhance population of target species, while an emphasis on ecosystem restoration, which supports “target species” is often more appropriate and effective.

Temptation is to address only limiting factors, without consideration of bigger picture

Objectives should be:

- Long-range
- Benefit all life stages and all species

4.1.3 Identify Stakeholders and Interests

Developing objectives should include all stakeholders and interests

Search for common ground among all impacted or interested parties

Stakeholders categories include:

- State and federal resource agencies
- Landowners
- Tribes
- Community and related businesses
- Hunters, anglers and other recreationists
- Environmental advocacy organizations

4.1.4 Identify Limitations to Accomplishing a Project

Discuss roadblocks, permitting requirements (generally) and restrictions. Logistical, project-specific hurdles.

In addition to constraints related to recovery potential discussed in 3.4.4, implementation of a project can be constrained by:

- Permitting – numerous permit requirements (which may sometimes conflict)—may lead to significant time delays (years), especially if endangered species may be positively or negatively impacted by project
- Number of regulatory entities
- Unwilling stakeholder(s)
- Details specific to the project
- Cost/funding

4.1.5 Expertise Required

Complexity of river system mandates understanding of many sciences

Successful projects should involve expertise from at least several related disciplines

These include:

- Hydrology and geomorphology
- Fish biology and aquatic ecology, including aquatic entomology
- Botany, plant ecology
- Wildlife and conservation biology

- Horticulture and agronomy of native plant materials
- Engineering - hydraulics and sediment transport

4.2 General Approaches

For each general approach listed below, discuss short-term and long-term nature, understanding of longevity of technique, maintenance, and appropriateness. List a few examples of techniques that may achieve the approach. (6-8 pages for following sections 4.2.1 to 4.2.4 in total)

Mitigation projects may be tied to specific mitigation targets as defined in Chapter 2, *Mitigation Planning*. The selection of a general approach in those cases may be determined by the required mitigation target.

4.2.1 Direct Creation of Specific Habitats

Discuss how may or may not pay attention to process. Discuss how might be most appropriate in a constrained system (such as an urban setting). Might be done for short-term solution in combination with another approach that satisfies long-term objective. Might be appropriate when used as mitigation with a target of restoration or replacement of pre-project conditions as defined in Chapter 2, *Mitigation Planning*.

- Projects – Process – List the types of projects (techniques) that might be more or less suitable for direct creation (side channels, debris jams, native riparian plant communities). Discussion should include ecological as well as geomorphic, hydrologic processes
- When appropriate?
- Discussion of appropriate scale (spatial / temporal, i.e., replacing riparian forest)
- Defining realistic goals and objectives
- Short term expectations
- Long term expectations
- Integration with natural processes or of current processes in constrained system.
- Longevity
- Maintenance
- Examples of techniques

4.2.2 Process Derived-Habitat Development

Encourage natural creation of habitat through natural disturbance processes and fluvial function. Fluvial function may operate on a (no hyphen needed on “site basis”) site-basis, through a specific structure which encourages process (such as scour or deposition), or on a reach basis through natural disturbance (channel migration, erosion, etc.)

- Process (natural vs. anthropogenic)
- Scale of process – site, reach, or watershed scales of process – stream hydrology (watershed)

affects cottonwood forest establishment via flooding; water availability, point bar/seed bed establishment (reach), which affects stream geomorphology through local scour, resistance to shear, erosion, wasting (reach, site)

- Artificial – when appropriate
- Types of applications
- Justification – goals and objectives
- Desired function – habitat / geomorphic function
- Mobility of structure - fate of large and small woody debris in system
- Integration with natural processes – to be effective, design must accommodate current and future expected conditions. These may be different than natural conditions.
- Short term expectations
- Long terms expectations – consideration of low frequency high (periodic flooding) and low flow (drought) events
- Examples –
- Site level – lwd, jams – create the structure that collects the jam material, scour structures
- Reach level - regulated river operations – which could constrain reestablishing riparian forest

4.2.3 *Manage Inputs to a Channel*

Discuss direct feeding of materials, including gravel and wood, into a channel without specialized placement.

- When appropriate? – as mitigation for lost opportunity as defined in Chapter 2, *Mitigation Planning*.
- Problem
- Identified Treatment – Woody Debris ~~LWD~~ loading, gravel replenishment, removal of bank armoring These listed here as examples. Each is a technique in its own.
- Appropriate scale –site vs. reach vs. watershed
- Justification / Rationale
- Goals and objectives
- Short term expectations – depends on flow events to create and maintain habitat
- Long term expectations – future watershed conditions, replenishment of material
- Constraints / Risk – risk within specific techniques of placing material in the stream that will be repositioned. See the specific techniques for additional information.
- Integration with natural processes
- Maintenance and operation

- Examples: gravel supplementation, wood nourishment – walk through case study – i.e., imitating beavers by dumping cottonwood, willow cuttings into stream systems, to settle out in lower energy sites and reaches to establish

4.2.4 Replication of Natural Conditions

Does not require understanding of process. This can be seen as one way of achieving each of the previous three general approaches. Results can be good or disastrous depending on whether or not the item copied was appropriate for the site and applied correctly. Highlight its shortcomings when used without consideration of process and its benefits when used in conjunction with a process-oriented approach

- When appropriate?
- Discussion of appropriate scale (spatial / temporal)
- Defining realistic goals and objectives
- Understanding limitations of reference conditions – is the reference reach appropriate in context of location or change in watershed condition, or size of contributing watershed?
- Is the reference reach really a reference reach or is it a novel assemblage of conditions which developed in response to a novel industrial era perturbation?
- Short term expectations
- Long term expectations
- Integration with natural processes / mobility / deformability
- Longevity
- Maintenance

4.3 Factors to Consider in Identifying and Selecting an Approach

(3-4 pages for following sections in total)

4.3.1 Resultant Conditions

Discuss result as ecological restoration, i.e., in context of other types of, or part of floodplain ecological restoration or rehabilitation.

Discuss result as “natural” conditions relative to current conditions, and the limitations to achieving natural conditions.

Discuss choice of building habitat and creating function; how they fit into schemes of time, longevity, risk, etc.

Generally discuss scale needed to make a function effective. How much of a levee setback is necessary to make it effective; how much of a cross section should be blocked to change hydraulics. How much of a reach should be included in a specific project to make it effective? Specifics would be in individual techniques.

What elements of riparian and floodplain ecosystems are contemplated as part of the restoration effort?

What are the challenges associated with working in large rivers versus small streams?

4.3.2 Delay to Results

Healthy natural systems are the product of complex interactions of multiple variables over time.

Restoration activities give a river a starting point, from which further interaction, and time, will bring about natural function and health.

Discuss lagtime to full function of various attributes:

- Food production – months to years
- Habitat – immediate if designed as direct habitat creation to supplement or jump-start the process restoration– processed-based restoration may depend on a series of high flow events
- Vegetation – decades to centuries
- Geomorphic function – immediate to years

Habitat mitigation projects must account for this lag time. Refer to Chapter 2, *Mitigation Planning*.

4.3.3 Longevity of Project

- Ideal is to strive for self-sustaining projects, thereby creating indefinite longevity
- Constructed projects, structural treatments will have a design life
- Generally, the default should be to design and implement self-sustaining projects with natural analogs rather than constructed projects which have design lives and no natural analogs.
- Design life is subject, however, to chance and random events, and land use and land tenure arrangements (land use regulation, easements, ownership)

4.3.3.1 Factors influencing longevity of treatments

- Hydrologic events and probability
- System stability and watershed impacts
- Recovery time to full potential
- Direct habitat creation and ~~vs~~ process restoration are two different design goals. A channel design project for habitat restoration may feature one or the other but usually both, in the following order of desirability when circumstances allow or can be made to allow:

- 1) Direct Hab. Rest. AND Process Restoration;
- 2) Process Restoration
- 3) Direct Habitat Restoration

In urban settings where restoring aboriginal geomorphic and hydrologic conditions is not possible, Direct Habitat Restoration is the priority. Lost function / lost opportunity during regeneration of habitat, requiring multiple growing seasons and multiple high flow events, beaver occupancy and activity over time, etc., makes Process Restoration alone less attractive than combining it with Direct Habitat Restoration.

- Future inputs of sediment and debris
- Land use regulations, easements and private, institutional or government ownership

4.3.4 *Operations and Maintenance Needs*

- Ideal is to strive for self-sustaining, maintenance-free projects, though In reality, seldom achieved ideal
- Need a discussion of (emphasis on) Washington examples of habitat restoration / channel design which are self-sustaining and maintenance free. By definition, if the design is process based or process derived, it should be self-sustaining.

In general, with permit conditions or natural channel / riparian habitat rehabilitation designs, there are two sets of criteria:

- 1) “DOABILITY” -- Is the proposal technically and financially sound and feasible (Is the design a good one that is supportable given existing hydrology, fluvial geomorphology? Is the design vision an accurate and ecologically appropriate reflection of reference reach or known previous channel morphology and riparian ecology? Are equipment, living and inert materials, and labor available? Is the timing right? Can weeds be controlled and irrigation supplied? Is the proposal funded?)?
 - 2) “DURABILITY” – What is the probability that the desired future condition will occur and persist in the landscape through time? What permit conditions, bid package provisions, contract provisions, expert construction oversight, performance bonding, contingency planning, environmental monitoring and inspection with stop work authority during construction, etc., are in place to assure the project is completed as designed, problems are addressed, weeds controlled, dead plant materials replaced in a timely way, long term monitoring happens, AND...the desired future condition is achieved and persists in the landscape through time.
- Operations and maintenance defined and examples provided

- Highlight that operations and maintenance is project specific, but that general guidelines are given for each technique.

4.3.5 Environmental Impact

Aquatic and terrestrial riparian systems are complex, involve interaction and response of numerous variables that change in magnitude spatially and temporally. Generally, any change to any inputs or variables, will result in change to process and habitat.

Consider possible environmental impact of project, on site and off-site (upstream and downstream):

- Aquatic impacts
- Riparian
- Terrestrial
- Marine

Projects invariably involve disturbance, often negative disturbance, though the end product justifies the temporary disturbance, if properly designed and constructed, and if ongoing monitoring and maintenance is conducted. HUGE IFS. See above discussion on “do-ability” and “durability”. For example, turbidity is always a factor in construction, even if dewatered. Risk of turbidity’s impact on resource can be reduced through BMPs and timing. Turbidity is not a good example, as it’s always short term and transient. Impacts to riparian plant communities, soil compaction, etc. are much more problematic and long-lived.

Spread of noxious weeds is a common and challenging negative impact from any soil disturbance in more arid portions of central and eastern Washington.

Impacts specific to various techniques are discussed in each technique

4.3.6 Risk Assessment/Certainty of Success

- The potential for project to cause damage to or compromise a natural resource is risk of the project.
- Long-term vs. short-term risks. Short term are relative to implementation/construction, long-term are relative to incongruity between project and the system it is in
- Risk of the project to properties and/or infrastructure
- Certainty of success is the likelihood that a project will meet its objective. Certainty varies among techniques, the level of design effort, the information available, and experience with the technique.
- Projects must be designed, funded, evaluated and permitted on the basis of two types of criteria, “do-ability” and “durability”

- Is the project technically and financially feasible?
- What provisions in contracting and permitting have been taken to assure successful completion, and persistence of the desired outcome in the landscape over time?

4.3.7 Cost Effectiveness

- Cost effectiveness is defined as cost of project per objective gained. Cost effectiveness will vary depending whether objective is short term or long term.
- Cost of project related to risk. Usually an inverse relationship.
- Cost may be relative to project implementation schedule – passive vs. active approaches. An example of an *active* approach is planting riparian vegetation. An example of a *passive* approach is fencing a riparian corridor, and waiting for an appropriate late seral stage riparian plant community to develop over time. While the same end goal may be achieved through a passive and an active approach, and passive is more cost effective, the waiting time may not justify savings

4.4 Process for Selecting Techniques

Couple pages plus a table.

A very important part of the guideline is the connection between desired results and action chosen. This summary should do that. Consider organizing it by coming from a reach perspective.

4.4.1 Some Channel Conditions Requiring Special Considerations

These are special situations that are often encountered and require special considerations and combinations of techniques.

- Aggrading channel - instability, no pools
- Degradation channel - no diversity, unstable or bedrock bed
- Confined channel - no floodplain habitat
- Channelized or constricted channel - lack of diversity, complexity, stability
- Lack of structure or roughness in channel to hold gravels
- Alluvial fan
- New channel design and construction for relocation or for habitat restoration

Discuss issues commonly found in each situation. The point here is to make the link between these general observations and recommendations that restore habitat as well as process.

4.4.2 Approaches to New Channel Design

New channels may be constructed for objectives of habitat restoration, mitigation of impacts of other

activities, or for relocation of the channel for other purposes. Use a group of techniques. Start with Channel Modifications as a basis for plan form, profile, and cross section. Add additional techniques for structure, habitat, and stability. Techniques from Integrated Streambank Protection Guidelines may also have to be included to provide structure until natural elements such as debris and vegetation develop.

4.4.3 Approaches to Solving Common Restoration Objectives

The following text and table show examples of what might be done to achieve common restoration objectives. These are broad suggestions as guidance and are not intended to limit the designer. Actual designs may include a combination of techniques.

4.4.3.1 Increase/restore salmonid spawning habitat

- \$ Encourage gravel sorting/cleaning through structure placement and channel modifications (*see Technique 5.5 Debris Jams, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.23 Replenish Woody Debris*)
- \$ Increase spawning area
 - \$ Increase length of stream (e.g. re-meander a channelized stream) (*see Technique 5.1 Channel Modification*)
 - \$ Restore, construct spawning, spring, or side channel (*see Technique 5.12 Side Channel Habitat*)
 - \$ Reconnect off-channel areas (*see Technique 5.1 Channel Modification, 5.4 Levee Removal and Setback, 5.19 Land Preservation and Buy Back*)
- \$ Encourage gravel stability (structure placement, channel configuration modification) (*see Technique 5.1 Channel Construction and Modification, 5.4 Levee Removal and Setback, 5.5 Debris Jams, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.14 Flow Management, 5.23 Replenish Woody Debris*)
- \$ Add spawning gravel – gravel placement, gravel feeding (*see Technique 5.10 Spawning Gravel*)
- \$ Clean gravel (e.g., Gravel Gertie) (*see Technique 5.10 Spawning Gravel*)
- \$ Control sediment (to control aggradation or abundance of fines)
 - \$ Implement upland BMPs or land use change to reduce fines delivered to stream (*see Technique 5.18 Sediment Control*)
 - \$ Increase sediment transport/maintenance of thalweg to prevent aggradation and resulting dredging
 - \$ structure placement (*see Technique 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity*)
 - \$ channel configuration modification (*see Technique 5.1 Channel Construction and Modification*)
 - \$ in-stream reed canary grass removal (*see Technique 5.25 Instream Grass Removal*)
 - \$ Install in-stream sediment detention basins (*see Technique 5.24 In-*

stream Detention Basins)

- \$ Install bank protection (*see Technique 5.20 Bank Protection*)

4.4.3.2 Increase/restore salmonid rearing habitat

- \$ Create pools (*see Technique 5.5 Debris Jams, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.23 Replenish Woody Debris, 5.23 Replenish Woody Debris*)
- \$ Add cover (wood, boulders, overhanging vegetation, undercut banks, pools, turbulence) (*see Technique 5.5 Debris Jams, 5.6 Log Cover, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.13 Riparian Management, 5.23 Replenish Woody Debris*)
- \$ Riparian management (*see Technique 5.13 Riparian Management*)
- \$ Create off-channel habitat (*see Technique 5.12 Side Channel Habitat*)
- \$ Reconnect off-channel areas (*see Technique 5.1 Channel Modification, 5.4 Levee Removal and Setback, 5.19 Land Preservation and Buy Back*)
- \$ Increase habitat diversity (*see Technique 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.23 Replenish Woody Debris*)
- \$ Provide high flow refuge (*see Technique 5.4 Levee Removal and Setback, 5.6 Log Cover, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.12 Side Channel Habitat, 5.23 Replenish Woody Debris*)
- \$ Control sediment (as above)

4.4.3.3 Improve water quality

- \$ Riparian management (*see Technique 5.13 Riparian Management*)
- \$ Restrict livestock access (*see Technique 5.13 Riparian Management*)
- \$ Stormwater management (*see Technique 5.14 Flow Management*)
- \$ Point and non-point source pollution management (*see Technique 5.17 Water Quality Improvement*)
- \$ Low-level nutrient replacement (e.g., salmon carcasses) (*see Technique 5.22 Nutrient Replacement*)
- \$ Control sediment (as above)

4.4.3.4 Restore hydrology

- \$ Stormwater management (*see Technique 5.14 Flow Management*)
- \$ Flood plain management (*see Technique 5.4 Levee Removal and Setback, 5.19 Land Preservation and Buy Back*)
- \$ Increase baseflows (*see Technique 5.14 Flow Management*)
 - \$ reduced or more efficient water diversions

- \$ stormwater storage and groundwater recharge
- \$ impoundment release management

4.4.3.5 Increase habitat diversity to benefit all species and life stages

See Technique 5.1 Channel Modification, 5.5 Debris Jams, 5.6 Log Cover, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.12 Side Channel Habitat, 5.23 Replenish Woody Debris

4.4.3.6 Restore habitat connectivity

- \$ Remove/modify levees (*see Technique 5.4 Levee Removal and Setback, 5.19 Land Preservation and Buy Back*)
- \$ Reconnect off-channel areas (*see Technique 5.1 Channel Modification, 5.4 Levee Removal and Setback, 5.19 Land Preservation and Buy Back*)
- \$ Floodplain management (*see Technique 5.19 Land Preservation and Buy Back*)
- \$ Reconnect flood plain (*see Technique 5.1 Channel Modification, 5.4 Levee Removal and Setback*)

4.4.3.7 Partially or fully restore self-maintaining proper functioning condition to channel to benefit all species

- \$ Restore channel planform (*see Technique 5.1 Channel Modification*)
- \$ Restore channel cross-section (*see Technique 5.1 Channel Modification*)
- \$ Restore bedform (*see Technique 5.1 Channel Modification, 5.5 Debris Jams, 5.6 Log Cover, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.23 Replenish Woody Debris*)
- \$ Reconnect flood plain (*see Technique 5.1 Channel Modification, 5.4 Levee Removal and Setback*)
- \$ Increase habitat diversity (*see Technique 5.1 Channel Modification, 5.5 Debris Jams, 5.6 Log Cover, 5.7 Boulders, 5.8 Structures to Create and Maintain Channel Bedform and Habitat Diversity, 5.12 Side Channel Habitat, 5.23 Replenish Woody Debris*)
- \$ Remove reed canary grass and other invasive species (*see Technique 5.13 Riparian Management, 5.25 In-stream Reed Canarygrass Removal*)
- \$ Increase buffer width (*see Technique 5.13 Riparian Management, 5.19 Land Preservation and Buy Back*)

4.4.3.8 Restore fish passage (see Technique 5.16 Fish Passage)

[illegible]

Construct New Channel	X		X	X	X	X	X	X	X		X						X		
Restore Fish Passage											X								

Some techniques are process oriented while others are direct, some provide immediate results while others take time to function as desired, some provide long-lasting results while others provide short-term results, some provide more predictable results than others. A combination of techniques will often need to be employed to fully meet the objectives of a single project.

4.5 Design Criteria (IFI)

(2-3 pages for following sections in total)

4.5.1 What are Design Criteria?

- Describe design criteria and how they relate to objectives
- Why criteria are applied and what function they serve in process
- How criteria relate to project objectives
- Differentiate between performance criteria and prescriptive criteria
- Make a single document out of the ISPG that will be sufficient for both documents. Borrow heavily from previous publications by Miller and Skidmore 2001, and from ISPG –

4.5.2 Examples of Design Criteria

- Relate design criteria to hydrologic statistics – base flow, effective discharge, flood flows
- Stability of structures relative to hydrologic events
- Project life criteria
- Performance criteria for revegetation efforts
- Performance criteria for fish use of habitat

4.5.3 How Design Criteria Relate to Monitoring

- Monitoring plan should be established to measure degree of success of meeting objectives
- Criteria established to meet objectives, therefore, criteria become basis for monitoring plan
- If performance criteria are used, then monitoring plan is established to measure performance relative to the criteria established

5 TECHNIQUES FOR HABITAT RESTORATION AND CHANNEL DESIGN PROJECTS

The following Five outline will be repeated for each individual habitat restoration technique. It will apply to each restoration technique but may vary among techniques. Brief introductions to techniques follow in the next section of this same document. Detailed outlines of each technique are available separately as individual documents but are not included at this point in time.

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Many of the techniques listed already exist as techniques for mitigation in the Integrated Streambank Guidelines. Where this is the case, the ISPG version will be used, with additions and revisions as appropriate such that a single document serves both the ISPG and the Habitat Restoration Guideline.

GENERAL OUTLINE FOR ALL TECHNIQUES

1 INTRODUCTION

1.1 *Description of Technique*

1.2 *Physical and Biological Effects*

Discuss the scientific basis for use of the technique and what are the biological effects. This refers to impacts and results including upstream and downstream.

1.3 *Application of Technique*

Discuss location, channel type, limitations; where it fits and where it doesn't fit – tie it to channel processes and reach considerations.

2 SCALE

Discuss how this technique can range in terms of scale, and whether additional specialized expertise (such as a licensed engineer) may be required (or at least advised).

3 RISK AND UNCERTAINTY

Risk of project not meeting objective, risk to other habitats, risk to infrastructure

4 DATA COLLECTION AND ASSESSMENT

This should include identifying potential reference reaches. Discuss other data that may be collected for empirical and analytical design approaches.

5 METHODS AND DESIGN

How is the design approached?

6 PROJECT IMPLEMENTATION

6.1 *Permitting*

Permitting will be covered generally in the chapters text. Where a specific technique may have some specific permitting considerations, describe them here.

6.2 *Construction*

Construction will be covered generally in the chapters text. Where a specific technique may have some

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specific construction considerations, describe them here.

6.3 *Cost Estimation*

Range of costs per unit, cite case examples with total project costs.

6.4 *Monitoring and Tracking*

What parameters should be monitored to address success of project and risks.

6.5 *Contracting Considerations*

Discuss aspects that may not be typical for contractors, or where specialty contractors may need to be utilized.

7 OPERATIONS AND MAINTENANCE

Discuss operations and maintenance needs, timing, frequency.

8 EXAMPLES

Description of example, with locations, sketches and photos.

9 REFERENCES

References cited in this technique so it is a stand-alone pullout.

LIST OF TECHNIQUES

1 501 CHANNEL MODIFICATION [HIGH]

- a. Include direct restoration (construct channel) and incremental process (build log jam that will tend to create islands that will restore natural divided channel rather than braided channel)
- a. Describe relationship to sediment transport. How do you size and configure a new channel?
- b. Includes all forms of channel modification including modification to planform, cross section and longitudinal profile.
- c. For all habitats.
- d. Supplement ISPG.

2 504 LEVEE REMOVAL AND SETBACK - [HIGH]

- a. Includes effect of levee removal that has been in place for decades and the channel has tried to evolve to it. Include how the floodplain is treated, risks of simple removal, and sequence of floodplain and channel restoration. Address the potential for detrimental effects of levee removal. Address how far back a levee has to go?
- b. For all habitats.

3 505 DEBRIS JAMS - [MODERATE]

- a. A process technique is a structure that restores a natural process though it may be done with a material that isn't natural. It isn't necessarily restoring full process. It could be something like building an artificial log jam that will restore natural functions and processes of roughness, scour, bed sorting, etc. Make the point that structures should only be used in the context of process design.
- b. Include full jams and debris catches.
- c. Supplement ISPG.
- d. For rearing, holding and spawning.

4 506 LOG COVER - [MODERATE]

- a. This is a simple log laid on the bank and crossing over a side scour pool as cover and flood refuge or a log buried in the bank cantilevered into the channel.
- b. For rearing and holding habitats.

5 507 BOULDERS – [MODERATE]

- a. Single and clusters.
- b. For rearing, holding and spawning (sorting and stability of bed material) habitat.

6 508 STRUCTURES TO MAINTAIN CHANNEL SCOUR - [MODERATE]

- a. Create scour for rearing, holding and spawning (sorting and stability of bed material) habitat. These aren't necessarily just specific structures. Random placement of debris performs a valuable function in some situations.
- b. Supplement info on groins and barbs in ISPG, but clarify difference in objectives (protection vs. creation through scour).
- c. To create and maintain diverse bedform and thalweg.
- d. To encourage gravel deposition/stabilization/sorting.
- e. Include rock piles, groins, deflectors, digger log, debris jams (detailed elsewhere), vortex rock weirs, rock J-hooks, "V" log weirs, "unstructured" debris placement.

7 510 SPAWNING HABITAT - [HIGH]

- a. Bed retention sills and pads.
- b. Gravel cleaning and loosening, gravel gertie
- c. For spawning, holding and rearing.
- d. May include spawning material placement .
- e. Culvert fish passage guideline includes good design and sketch of single log sill. Need to add "vee" weir sketch.
- f. Pads in channels with spring water hydrology or in channels with appropriate hydraulics but depleted of gravel.

8 512 SIDE CHANNEL HABITATS – [MODERATE]

- a. Connection, construction and protection of ground and surface water fed side channels.
- b. Include opening floodgates, debris jams to meter flow into side channels.
- c. Supplement ISPG.

9 513 RIPARIAN MANAGEMENT – [MODERATE]

- a. To create cover, stabilize banks, improve water quality, shade out in-channel reed canary grass, provide long-term source of large woody material).
- b. Refer to PHS Riparian document and Planting and Erosion Control Appendix of ISPG.

10 514 FLOW MANAGEMENT – [LOW]

- a. Stormwater management, water diversions, and in-stream flow.
- b. Refer to other documents. For stormwater, refer to WA Dept of Ecology's

Stormwater Manual. For water diversions, appropriate documents will need to be located. The USDA Natural Resources Conservation Service is the most likely place to lead people for BMPs and irrigation systems that reduce landowner's use of water as well as efficient canal design. For instream flow, there are several documents on the WA Dept of Ecology's web site. The primary one of interest is called "In-stream flow study guidelines" and was written jointly between WA Dept of Ecology and WA Dept of Fish and Wildlife.

11 516 FISH PASSAGE RESTORATION – [Low]

- a. Refer to Fish Passage at Road Culverts and Fishway Design manuals

12 517 WATER QUALITY IMPROVEMENTS - [Low]

- a. Refer to other documents. A key to this effort is to not reinvent existing work that is adequate. We don't expect to provide technical information here or to paraphrase. We expect to describe the value of stormwater management for habitat restoration and to say for example, "no guidance is provided in these guidelines for stormwater management, refer to the current version of the Ecology Stormwater Manual for guidance."
- b. Point and non-point source pollution management. References will need to be determined. The WA Dept of Ecology's Stormwater Manual will provide some of this with regards to urban BMPs. The USDA Natural Resources Conservation Service will be a reference for agricultural BMPs.
- c. Stormwater management. Refer to WA Dept of Ecology's Stormwater Manual.
- d. Describe the value in habitat restoration.
- e. Refer to other documents.

13 518 SEDIMENT CONTROL – [Low]

- a. Road decommissioning, land use practice modification, riparian zone restoration, stormwater management, upland sediment detention basins, restrict livestock access, and road cleaning.
- b. General discussion; refer to other documents. The WA Dept of Natural Resources Forest Practice Act will be a reference for road decommissioning and BMPs related to logging operations. The USDA Natural Resources Conservation Service will be the most likely reference for upland sediment detention basins, restricting livestock access, and agricultural BMPs to reduce upland erosion. The WA Dept of Ecology's Stormwater Manual may provide urban BMPs for sediment control.

14 519 LAND PRESERVATION, BUY-BACK AND FLOODPROOFING - [Low]

These techniques allow the river to continue functioning. Don't describe the "how to do it," just

mention the opportunity. They may also be used in conjunction with something like floodplain reconnection as an overall restoration effort. COMMENT: we've discussed adding other floodplain actions. We need to draw the line to keep this manageable. I suggest we include actions that individuals can undertake as mitigation. That would not include habitat protection by land-use planning.

15 520 BANK PROTECTION – [Low]

- a. Refer to ISPG.
- b. Primarily describe when bank protection can legitimately be considered restoration.

16 522 NUTRIENT REPLACEMENT – [Low]

- a. Salmon carcasses.
- b. Refer to WDFW carcass policy.

17 523 WOODY DEBRIS REPLENISHMENT – [MODERATE]

- a. Bring it to the stream and let the river put it where it wants.

18 524 IN-STREAM SEDIMENT DETENTION BASINS – [Low]

- a. Supplement ideas from Sand and Gravel Mining document white paper. This will be a technique in that guideline.

19 525 IN-STREAM REED CANARY GRASS REMOVAL (DREDGING AND HERBICIDES) - [Low]

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TECHNICAL APPENDICES

The intention will be to build on the appendices prepared for the ISPG so that they can be used for both, rather than having different appendices of the same name. Appendices will serve the purpose of providing technical information and explanation of various aspects of design and act as a reference source for practitioners. Where ISPG appendices are sufficient as they already exist, these appendices may require little or no effort or modification. Numbers of pages listed are the equivalent of new work for this contract.

Hydrology (2 pages)

Fluvial Geomorphology (2 pages)

Sediment Transport (2 pages)

Hydraulics (2 pages)

Riparian Vegetation (2 pages – supplements riparian management technique)

Aquatic Habitat (4 pages – written by WDFW for ISPG)

GLOSSARY

A glossary will be included.